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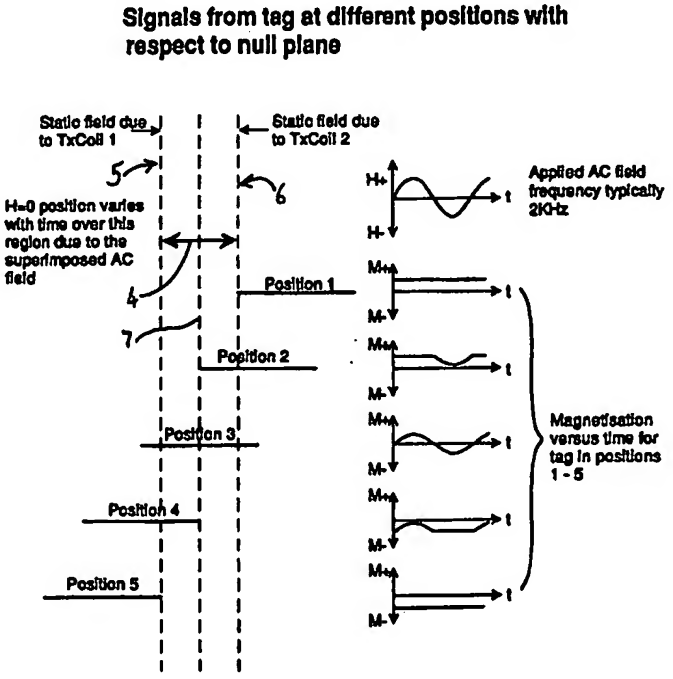
(57) Abstract

Magnetic tags or markers are disclosed, together with a variety of techniques by means of which such tags may be interrogated. In one aspect, the magnetic marker or tag which is characterised by carrying a plurality of discrete magnetically active regions in a linear array. In another aspect, the invention provides a method of interrogating a magnetic tag or marker within a predetermined interrogation zone, the tag comprising a high permeability magnetic material, for example to read data stored magnetically in the tag or to use the response of the tag to detect its presence and/or to determine its position within the interrogation zone, characterized in that the interrogation process includes the step of subjecting the tag sequentially to: (1) a magnetic field sufficient in field strength to saturate the high permeability magnetic material, and (2) a magnetic null as herein defined. Applications of such techniques are described, *inter alia*, in relation to (a) identifying articles to which tags are attached; (b) accurate determination of position, as in the location of surgical probes; and (c) totalisation of purchases, where each item carries a tag coded with data representing its nature and its price.



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AMENDED CLAIMS
[received by the International Bureau on 25 September 1996 (25.09.96);
original claims 1-46 replaced by amended claims 1-53 (11 pages)]

1. A magnetic marker or tag which is characterised by carrying a plurality of discrete magnetically active regions in a linear array.

2. A tag as claimed in claim 1, characterised in that said discrete magnetically active regions are supported on a substrate.

3. A tag as claimed in claim 1 or 2, characterised in that said discrete magnetically active regions are formed from a continuous strip or layer of magnetisable material discrete regions of which are magnetised and the space(s) between said magnetically active regions are non-magnetised.

4. A tag as claimed in claim 3, characterised in that said layer of magnetisable material is carried by a continuous strip of a magnetically active material.

5. A tag as claimed in claim 1, 2, 3 or 4, characterised in that the tag has two or more linear arrays of magnetically active regions.

6. A tag as claimed in claim 5, characterised in that the tag has two linear arrays disposed orthogonally.

7. A tag as claimed in any preceding claim, characterised in that each of the magnetically active regions is of substantially the same shape and size.

8. A tag as claimed in any preceding claim, characterised in that the spacing between each of the magnetically active regions is uniform.

9. A tag as claimed in any one of claims 1 to 7, characterised in that the spacing between each of the magnetically active regions is non-uniform.

10. A tag as claimed in any preceding claim, characterised in that it is in the form of a relatively long, thin strip having a preferential axis of magnetisation along its length.

11. A tag as claimed in any preceding claim, characterised in that the magnetically active regions are formed of a thin film, spin-melt material having a preferential axis of magnetisation, the preferential axes of magnetisation being aligned within the (or each) linear array.

12. A tag as claimed in claim 10, characterised in that the preferential axes of magnetisation are generated by longitudinal annealing of the thin film, spin-melt material.

13. A method of interrogating a magnetic tag or marker within a predetermined interrogation zone, the tag comprising a high permeability magnetic material, for example to read data stored magnetically in the tag or to use the response of the tag to detect its presence and/or to determine its position within the interrogation zone, characterised in that the interrogation process includes the step of subjecting the tag sequentially to: (1) a magnetic field sufficient in field strength to saturate the high permeability magnetic material, and (2) a magnetic null as herein defined.

14. A method as claimed in claim 13, characterised in that said magnetic null is caused to sweep back and

forth over a predetermined region within the interrogation zone.

15. A method as claimed in claim 13 or 14, characterised in that (a) said magnetic null lies in a plane; and (b) the saturating field occurs adjacent to said plane.

16. A method of determining the presence and/or the position of a magnetic element within a predetermined interrogation zone, the magnetic element having predetermined magnetic characteristics, which method is characterised by the steps of: (1) establishing within said interrogation zone a magnetic field pattern which comprises a relatively small region of zero magnetic field (a magnetic null) contiguous with regions where there is a magnetic field sufficient to saturate the, or a part of the, magnetic element (the saturating field), said relatively small region being coincident with a region through which the magnetic element is passing, or can pass, or is expected to pass; (2) causing relative movement between said magnetic field and said magnetic element such that said magnetic null is caused to traverse at least a part of the magnetic element in a predetermined manner; and (3) detecting the resultant magnetic response of the magnetic element during said relative movement.

17. A method of identifying a magnetic element which possesses predetermined magnetic characteristics, which method is characterised by the steps of: (1) subjecting the magnetic element to a first magnetic field which is sufficient to induce magnetic saturation in at least a part of the magnetic element; (2) next subjecting the magnetic element to conditions of zero magnetic field

(i.e. a magnetic null), the zero field occupying a relatively small volume and being contiguous with said first magnetic field; (3) causing relative movement between the applied magnetic field and said magnetic element such that said magnetic null is caused to traverse at least a part of the magnetic element in a predetermined manner; and (4) detecting the resultant magnetic response of the magnetic element during said relative movement.

18. A method according to claim 17, characterised in that said magnetic element is caused to traverse an interrogation zone within which the required magnetic conditions are generated.

19. A method of identifying a magnetic element, the magnetic element having predetermined magnetic characteristics, which method is characterised by the steps of: (1) causing the magnetic element to enter an interrogation zone within which there is established a magnetic field pattern which comprises a relatively small region of zero magnetic field (a magnetic null) contiguous with regions where there is a magnetic field sufficient to saturate the, or a part of the, magnetic element (the saturating field); (2) causing the magnetic element to be moved through the saturating field until it reaches the magnetic null; (3) causing relative movement between said magnetic field and said magnetic element such that said magnetic null is caused to traverse at least a part of the magnetic element in a predetermined manner; and (4) detecting the resultant magnetic response of the magnetic element during said relative movement.

20. A method according to claim 16, 17, 18 or 19, characterised in that said relative movement is

produced by sweeping the applied magnetic field over the magnetic element.

21. A method according to any one of claims 13 to 20, characterised in that said magnetic element is generally elongate and in that the zero field direction of said magnetic null is arranged to extend along the major axis of said magnetic element.

22. A method according to any one of claims 13 to 20, characterised in that said magnetic element is in the form of a thin film and in that the zero field direction of said magnetic null is arranged to be aligned with the axis of magnetic sensitivity of the film.

23. A method as claimed in any one of claims 13 to 22, characterised in that said magnetic field or magnetic field pattern is established by the application to said spatial volume or to said interrogation zone of two magnetic fields of opposite polarity.

24. A method as claimed in claim 23, characterised in that the application of said two magnetic fields is achieved by use of one or more coils carrying direct current.

25. A method as claimed in any one of claims 13 to 24, characterised in that said magnetic field or magnetic field pattern is established by the use of one or more permanent magnets.

26. A method according to claim 24, characterised in that said coil(s) carry/carries a substantially constant current so as to maintain the magnetic null at a fixed point.

27. A method according to claim 24, characterised in that said coil(s) carry/carries a current whose magnitude varies in a predetermined cycle so that the position of the magnetic null is caused to oscillate in a predetermined manner.

28. A method according to claim 25, characterised in that said permanent magnet(s) is or are accompanied by a coil or coils which carry or carries a current whose magnitude varies according to a predetermined cycle so that the position of the magnetic null is caused to oscillate in a predetermined manner.

29. A method as claimed in any one of claims 16 to 28, characterised in that said relative movement is caused by the application to said magnetic field or magnetic field pattern of an alternating magnetic field.

30. A method of determining the presence and/or the position of a magnetic element, which is characterised by the steps of: (1) applying a magnetic field to a region where the magnetic element is, or is expected to be, located, said magnetic field comprising two opposed field components, generated by at least one magnetic field source, which result in a null field at a predetermined position; (2) causing relative movement between said magnetic field and said magnetic element; and (3) detecting the resultant magnetic response of the magnetic element during said relative movement.

31. A method according to claim 29 or 30, characterised in that relative movement between said magnetic field and said magnetic element is caused by applying a relatively low amplitude alternating magnetic field superimposed on a DC field.

32. A method according to claim 31, characterised in that said relatively low amplitude alternating magnetic field has a frequency in the range from 10Hz to 100kHz.

33. A method according to any one of claims 13 to 32, characterised in that detection of the magnetic response of said magnetic element comprises observation of harmonics which are generated by the magnetic element from an applied AC field as its magnetisation state is altered by passing through the magnetic null.

34. A method of determining the precise location of an object, characterised in that the method comprises: (a) securing to the object a small piece of a magnetic material which is of high magnetic permeability; (b) applying to the region in which said object is located a magnetic field comprising two opposed field components, generated by magnetic field sources, which result in a null field at a position intermediate said magnetic field sources; (c) applying a low amplitude, high frequency interrogating field to said region; (d) causing the position of the null field to sweep slowly back and forth over a predetermined range of movement; (e) observing the magnetic interaction between said applied magnetic field and said small piece of magnetic material; and (f) calculating the position of the object from a consideration of said magnetic interaction and form the known magnetic parameters relating to said applied field and to said small piece of magnetic material.

35. A method according to claim 34, characterised in that said object is a surgical instrument.

36. A method according to claim 35, characterised in that said object is a surgical probe or needle.

37. A method according to claim 34, 35 or 36, characterised in that said small piece of high magnetic permeability magnetic material is in the form of a thin foil, a wire or a thin film.

38. A method according to any one of claims 34 to 37, characterised in that said magnetic field sources are coils.

39. A method according to any one of claims 34 to 37, characterised in that one or both of said magnetic field sources is/are permanent magnet(s).

40. A method according to any one of claims 34 to 39, characterised in that the applied magnetic field is generated by three sets of mutually orthogonal magnetic field sources.

41. A method according to claim 39 or 40, characterised in that the applied magnetic field is generated by operating sequential field scans and calculating, for each scan, the position of the centre of the harmonic output from the magnetic material.

42. A method according to claim 41, characterised in that there are nine sequential field scans, operated according to the following table, in which the magnetic field sources are identified as **a**, **b** and **c** and the scans are numbered from 1-9 (scanning order being of no significance):

Orthogonal field source	1	2	3	4	5	6	7	8	9
a	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON
b	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
c	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON

43. A method according to claim 40, characterised in that three orthogonal coil sets are continuously excited so as to create a continuously rotating field direction which covers the volume of interest in controlled sweeps of predetermined width.

44. A method of coding and/or labelling individual articles within a predetermined set of articles by means of data characteristic of the articles, e.g. article price and/or the nature of the goods constituting the articles, which method is characterised by applying to each article a magnetic tag or marker carrying a predetermined arrangement of magnetic zones unique to that article or to that article and others sharing the same characteristic, e.g. article price and/or the nature of the goods constituting the article, said magnetic tag or marker being susceptible to interrogation by an applied magnetic field to generate a response indicative of the magnetic properties of the tag or marker and hence indicative of the nature of the article carrying the magnetic tag or marker.

45. A method according to claim 44, characterised in that said magnetic tag or marker comprises a plurality of magnetic zones each displaying high permeability.

46. A method according to claim 45, characterised in that each magnetic zone can be magnetically biassed by means of a second layer of medium-coercivity magnetic material.

47. A method of totalising data (e.g. prices) from an assembly of individual articles each carrying a magnetic tag as claimed in any one of claims 1 to 11, the tags carrying data representative of a specific characteristic (e.g. price) of the article to which they are attached, characterised in that the assembly of articles is caused to move through an interrogation zone where the assembly is subjected to a method as claimed in any one of claims 39 to 42; and processing the signals received during said method to generate the required summing of individual datum values.

48. A device for reading a magnetic tag, which device comprises a plurality of permanent magnets disposed in a circular array around a gap through which a tag to be read can pass, the poles of said permanent magnets being disposed so that each of the magnets has its pole of one polarity (for example North) positioned on the inside of the circular array, and its pole of the opposite polarity (for example South) positioned on the outside of the circular array; and a coil disposed coaxially with said circular array adjacent to said permanent magnets.

49. A device for reading a magnetic tag, which device comprises a plurality of permanent magnets disposed in a circular array around a gap through which a tag to be read can pass, the permanent magnets being disposed such that for each of them its magnetic poles lie on an imaginary line extending radially outwardly from the centre of said circular array, poles of one given

polarity all being positioned radially inwardly and poles of the opposite polarity all being positioned radially outwardly of the array; and a coil disposed within said circular array adjacent to said permanent magnets.

50. A device as claimed in claim 48 or 49, wherein said circular array of permanent magnets consists of an even number of permanent magnets.

51. A device as claimed in claim 48, 49 or 50, wherein said permanent magnets are polymer-bonded ferrite magnets.

52. A position sensor which includes a device as claimed in claim 48, 49, 50 or 51.

53. Apparatus for interrogating a magnetically coded tag, which apparatus is characterised by an electrical circuit which comprises a source of energy at frequency 2f and output means for providing an electrical output, said source being coupled to said output means by (i) means for halving the frequency of said source energy; (ii) first filter means arranged substantially to reject energy at frequency 2f; (iii) tuned circuit means tuned to energy at frequency f and including a transmitter coil adapted to radiate energy towards a magnetically coded tag positioned so as to be influenced by said radiated energy and a receiver coil (which may be the same coil as said transmitter coil) for receiving energy radiated by the tag in response to the received energy; and (iv) second filter means arranged substantially to reject energy at frequency f and to pass energy at frequency 2f, and wherein said output means is arranged to provide an output which is a function of the phase difference between the source and the output of said second filter means.